

NBS

PUBLICATIONS

A11102 616166

NAT'L INST OF STANDARDS & TECH R.I.C.



A11102616166

Humphreys, J. C./Cobalt-60 facilities ava  
QC100 .U56 NO.86-3480 1986 V19 C.1 NBS-P

3480

# Cobalt-60 Facilities Available for Hardness Assurance Testing

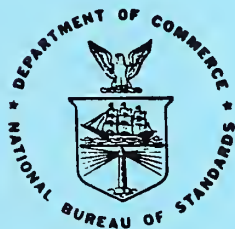
---

J. C. Humphreys and Charles M. Dozier

U.S. DEPARTMENT OF COMMERCE  
National Bureau of Standards  
National Measurement Laboratory  
Center for Radiation Research  
Ionizing Radiation Division  
Gaithersburg, MD 20899

This work sponsored by Defense Nuclear  
Agency under Project RV, Task RA and  
Work Unit 119.

November 1986



U.S. DEPARTMENT OF COMMERCE  
NATIONAL BUREAU OF STANDARDS

QC

100

.U56

#86-3480

1986

c.2



NBS  
01/100

01/100

100-10000

1/100

1/2

NBSIR 86-3480

## **COBALT-60 FACILITIES AVAILABLE FOR HARDNESS ASSURANCE TESTING**

---

J. C. Humphreys and Charles M. Dozier

U.S. DEPARTMENT OF COMMERCE  
National Bureau of Standards  
National Measurement Laboratory  
Center for Radiation Research  
Ionizing Radiation Division  
Gaithersburg, MD 20899

This work sponsored by Defense Nuclear  
Agency under Project RV, Task RA and  
Work Unit 119.

November 1986

**U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, *Secretary***  
**NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Director***



Cobalt-60 Facilities Available  
For Hardness Assurance Testing

ABSTRACT

This report contains a list of cobalt-60 gamma-ray irradiation facilities that are available for hardness assurance testing of electronic devices. A summary of source type, absorbed-dose rates, experimental volume available, and other pertinent information is given for each facility.

Key Words: absorbed-dose rate, cobalt-60 facility, gamma rays, irradiation volume, radiation hardness testing.



## A. INTRODUCTION

Many organizations occasionally need access to cobalt-60 facilities for gamma-ray irradiation of microelectronic devices or systems as part of a hardness assurance testing program. Some of these organizations have in-house irradiation facilities. For those organizations that do not, facilities listed in this report can provide such services. The list summarizes the pertinent information about each facility such as source type, absorbed-dose rates available, irradiation volume, user contact points, etc. The facilities listed are wide-spread geographically, but are not inclusive. An earlier list included all known facilities worldwide, but gave no details other than the operator and plant designer [1].\*

If the reader represents an organization that he feels should be on the list, he should contact one of the authors. It is planned that the list will be revised periodically and reissued to keep it as current as possible.

The list of characteristics for each facility is summarized from information supplied by the facility operator and, in some cases (such as absorbed dose rates), may be only approximations, due to such variables as source geometry. A prospective user should communicate with the contact person listed at the facility for the latest and most accurate information.

The facilities listed have been designed for a wide variety of applications. The energy spectral characteristics of many of them probably are not well known. Calculations of the energy spectra of a few types of sources have been made and indicate

that significant low-energy components exist for certain geometries [2, 3]. These low-energy components may cause serious dosimetry errors due to absorbed dose enhancement effects near interfaces. As a result, it is recommended that all testing be conducted with the devices-under-test and the dosimeters contained within a lead-aluminum filter box. A discussion of the potential dosimetry errors and recommended material thicknesses for such a filter box are given in reference [4].

-----  
\*Figures in brackets indicate the literature references which are listed at the end of this report.



## REFERENCES

1. "World List of Industrial Gamma Irradiators", compiled by Atomic Energy of Canada Ltd., Association of International Industrial Irradiation, Newsletter No. 12, pp. 163-167, (Oct 1984).
2. Woolf, S., and Frederickson, A.R., "Photon Spectra in  $^{60}\text{Co}$ - $\gamma$  Test Cell", IEEE Trans. Nuc. Sci., NS-30, pp. 4371-4376 (1983).
3. Woolf, S., and Burke, E.A., "Monte Carlo Calculations of Irradiation Test Photon Spectra", IEEE Trans. Nuc. Sci., NS-31, pp. 1089-1094 (1984).
4. Brown, D.B., and Dozier, C.M, "Reducing Errors in Dosimetry Caused by Low Energy Components of Co-60 and Flash X-Ray Sources", IEEE Trans. Nuc. Sci., NS-29 pp. 1996-1999 (1982).

ORGANIZATION: Armed Forces Radiological Research  
Institute  
Bethesda, MD

TYPE OF SOURCE: H<sub>2</sub>O pool, 33' by 33' by 33'.  
Samples can be placed in interior of  
source region.

MAXIMUM ABSORBED  
DOSE RATE (in Si):  $4 \times 10^5$  rad/h

USABLE IRRADIATION VOLUME: Central region 8" by 8" by 14"

TEMPERATURE RISE DURING IRRADIATION: None

COST: Depends on test

USER PRIVILEGES: AFRRI operates source. User sets up  
and runs experiment.

CONTACT: Capt. Leonard Alt  
Armed Forces Radiological Research  
Institute  
NMC-NCR  
Bethesda, MD 20814  
Telephone: (202) 295-1096

ORGANIZATION: Battelle Memorial Institute  
Columbus, OH

TYPE OF SOURCE: Room source, 3300 Curies (acquiring 50  
kCuries in near future). Sources are  
cylindrical rods which are arranged for test.

MAXIMUM ABSORBED  
DOSE RATE (in Si):  $1 \times 10^6$  rad/h

USABLE IRRADIATION VOLUME: 9' by 25' by 30'

TEMPERATURE RISE DURING IRRADIATION: None

COST: Depends on test - Typical test programs \$5K-10K

USER PRIVILEGES: Operator supplied for source. User free  
to control and operate own test equipment.

CONTACT: Dr. V. Pasupathi  
Battele Columbus Laboratories  
505 King Avenue  
Columbus, OH 43201  
Telephone: (614) 879-5140

ORGANIZATION: Boeing Aerospace Company  
Seattle, WA

TYPE OF SOURCE: (1) Gammacell 220  
(2) Gammacell 220  
(3) Gammacell 200  
(4) Gamma Lab (room)

MAXIMUM ABSORBED

DOSE RATE (in Si): (1)  $1 \times 10^6$  rad/h  
(2)  $4 \times 10^5$  rad/h  
(3)  $6 \times 10^3$  rad/h  
(4)  $9 \times 10^3$  rad/h

USABLE IRRADIATION VOLUME: (1) and (2) 6" dia. by 8" height  
(3) 3.5" dia. by 5.5" height  
(4) 5' by 15' room

TEMPERATURE RISE DURING IRRADIATION: Up to 37°C

COST: \$800/Day

USER PRIVILEGES: Unlimited within established operating  
procedures. Automated test equipment  
is available.

CONTACT: Mr. Dennis Russell  
Boeing Aerospace Company  
P.O. Box 3999  
Seattle, WA 98124  
Mail Stop 2R-00  
Telephone: (206) 655-6712

OPERATION: Brookhaven Gamma-Irradiation Facilities  
Brookhaven National Laboratory  
Upton, New York

TYPE OF SOURCE: Water Pool

MAXIMUM ABSORBED  
DOSE RATE(in Si):  $4 \times 10^6$  rad/h

USABLE IRRADIATION VOLUME: 4" diameter by 10" height  
in center of source

TEMPERATURE RISE DURING IRRADIATION: N/A

COST: N/A

USER PRIVILEGES: Staff inserts sample

CONTACT: Mr. Walter Becker  
Brookhaven National Laboratory  
Bldg. 830  
Upton, NY 11973  
Telephone: (516) 282-4533 or 4526

ORGANIZATION: General Electric Company  
Utica, NY

TYPE OF SOURCE: AECL Gammacell 220

MAXIMUM ABSORBED  
DOSE RATE (in Si):  $6 \times 10^5$  rad/h

USABLE IRRADIATION VOLUME: 6" dia. by 8" height

TEMPERATURE RISE DURING IRRADIATION: N/A

COST: Depends on test program

USER PRIVILEGES: Users may do their own irradiations  
under staff supervision. Visitors must  
have a security clearance and be escorted to  
and from the facility.

CONTACT: Mr. Charles M. Hewison  
General Electric Company  
Aerospace Electronic Products Dept.  
French Road  
Utica, NY 13502  
Telephone: (315) 793-5375

ORGANIZATION: General Electric Company  
Space Division  
Valley Forge, Pennsylvania

TYPE OF SOURCE: Gammacell 220

MAXIMUM ABSORBED  
DOSE RATE (in Si):  $2 \times 10^5$  rad/h

USABLE IRRADIATION VOLUME: 6" dia. by 8" height

TEMPERATURE RISE DURING IRRADIATION: Monitored

COST: Approx \$900/day (includes technician support)

USER PRIVILEGES: User can operate with technician support.  
Automated test equipment for up to 24 pin  
devices available. GE will also do all test-  
ing and supply test results.

CONTACT: Mr. Larry C. Jeffers  
P.O. Box 8555  
Philadelphia, PA 19101  
Telephone: (215) 962-3811 x3196

ORGANIZATION: Georgia Institute of Technology  
Atlanta, Georgia

TYPE OF SOURCE: Room source - stored in H<sub>2</sub>O  
pool. Have 8 source frames and  
5 cylindrical sources.  
30 ports for 1" cables.

MAXIMUM ABSORBED  
DOSE RATES (in Si):  $3 \times 10^6$  rad/h

USABLE IRRADIATION VOLUME 7' by 13' by 23'

TEMPERATURE RISE DURING IRRADIATION: Max 50°C

COST: \$850/day

USER PRIVILEGES: User operates own equipment. Institute  
operates source and can provide calculations,  
dosimetry and pictures.

CONTACT: Mr. Jerry Taylor  
Georgia Institute of Technology  
Frank H. Neely Nuclear Research Center  
900 Atlantic Drive, NW  
Atlanta, GA 30332  
Telephone: (404) 894-3608



ORGANIZATION: Hughes Aircraft Company  
El Segundo, CA

TYPE OF SOURCE: (1) Gammacell 220  
(2) GR9  
(3) GR9

MAXIMUM ABSORBED

DOSE RATE (in Si): (1)  $2 \times 10^6$  rad/h  
(2)  $2 \times 10^5$  rad/h  
(3)  $4 \times 10^4$  rad/h

USABLE IRRADIATION VOLUME: (1) 6" dia. by 8" height  
(2) and (3) 4" dia. by 5" height

TEMPERATURE RISE DURING IRRADIATION: Negligible

COST: Depends on test procedure

USER PRIVILEGES: HAC operates source, will do testing for  
user, or allow user to run own test program.

CONTACT: Mr. Joe Zeleck  
Hughes Aircraft Company  
P.O. Box 902  
Bldg. E-2 MS-S107  
El Segundo, CA 90245  
Telephone: (213) 616 -0277

ORGANIZATION: International Nutronics  
Irvine, CA

TYPE OF SOURCE: 1.6 MCuries in 195 cylindrical rods.  
Source also used for medical and food  
irradiations.

MAXIMUM ABSORBED  
DOSE RATE (in Si):  $5 \times 10^6$  rad/h

USABLE IRRADIATION VOLUME: 20' by 40' room

TEMPERATURE RISE DURING IRRADIATION: Room temperature

COST: Depends on test

USER PRIVILEGES: Company supplies dosimetry and operates  
source. Experimenter operates own equip-  
ment.

CONTACT: Mr. Robert Baldwin  
International Nutronics  
1962 Barranca Rd.  
Irving, CA 92714  
Telephone: (714) 863-9361

ORGANIZATION: International Nutronics  
Palo Alto, CA

TYPE OF SOURCE: 250 kCuries in 48 cylindrical rods.  
Source also used for medical and food  
irradiations.

MAXIMUM ABSORBED  
DOSE RATE (in Si):  $3 \times 10^6$  rad/h

USABLE IRRADIATION VOLUME: 10' by 12' room

TEMPERATURE RISE DURING IRRADIATION: Room temperature

COST: Depends on test

USER PRIVILEGES: Company supplies dosimetry and operates  
source. Experimenter operates own equip-  
ment.

CONTACT: Mr. Tom Rensel  
International Nutronics  
1237 N. San Antonio Road  
Palo Alto, CA 94303  
Telephone: (415) 968-5257

ORGANIZATION: IRT Corporation  
San Diego, CA

TYPE OF SOURCE: Gammacell 220

MAXIMUM ABSORBED  
DOSE RATE (in Si):  $3 \times 10^5$  rad/h

USABLE IRRADIATION VOLUME: 6" dia. by 8" height

TEMPERATURE RISE DURING IRRADIATION: Approx. 3°C per Mrad

COST: Negotiable

USER PRIVILEGES: Staff operated

CONTACT: Mr. John Harrity  
IRT Corporation  
3030 Callan Rd.  
San Diego, CA 92121  
Telephone (619) 450-4343

ORGANIZATION: Jet Propulsion Laboratory  
Pasadena, CA

TYPE OF SOURCE: Room source. Two Co-60 sources on rails.

MAXIMUM ABSORBED  
DOSE RATE (in Si):  $3 \times 10^5$  rad/h

USABLE IRRADIATION VOLUME: 20' by 20' by 14'

TEMPERATURE RISE DURING IRRADIATION: Room temperature

COST: Evaluated case-by-case

USER PRIVILEGES: Licensed operator required to operate  
source. User allowed to run the experi-  
ment.

CONTACT: Mr. Michael Gauthier  
Jet Propulsion Laboratory  
MS-T1180  
4800 Oak Grove Drive  
Pasadena, CA 91109  
Telephone: (818) 354-2126

ORGANIZATION: Martin Marietta Aerospace  
Orlando, FL

TYPE OF SOURCE: J.L. Shepard Model 109 -- 6 rods in Pb  
shielding container. H<sub>2</sub>O cooled.

MAXIMUM ABSORBED  
DOSE RATE (in Si):  $7 \times 10^5$  rad/h

USABLE IRRADIATION VOLUME: 3" dia. by 6" height

TEMPERATURE RISE DURING IRRADIATION: None

COST: Depends on test

USER PRIVILEGES: Operator is supplied. Have electronics  
for tests. Will do testing.

CONTACT: Mr. Jim Simmons  
Martin Marietta Aerospace  
P.O. Box 5837  
MS-163  
Orlando, FL 32855  
Telephone: (305) 356-4458

ORGANIZATION: National Bureau of Standards  
Gaithersburg, MD

TYPE OF SOURCE: (1) AECL Gammacell 220  
(2) Pool source: 12 source pencils  
in cylindrical array  
(3) Teletherapy collimated beam  
source

MAXIMUM ABSORBED

DOSE RATE (in Si): (1)  $1 \times 10^6$  rad/h  
(2)  $4 \times 10^5$  rad/h  
(3)  $1 \times 10^3$  rad/h

USABLE IRRADIATION VOLUME: (1) 6" dia. by 8" height  
(2) 3" dia. by 4" height  
(3) 12" dia. collimated beam

TEMPERATURE RISE DURING IRRADIATION: (1)  $-40^{\circ}\text{C}$   
(2) none  
(3) none

COST: Depends on Test

USER PRIVILEGES: Source operator provided. User  
provides and operates own test  
equipment.

CONTACT: Mr. J. C. Humphreys  
National Bureau of Standards  
C216 Radiation Physics Building  
Gaithersburg, MD 20899  
Telephone: (301) 921-2201

ORGANIZATION: Naval Research Laboratory  
Washington, DC

TYPE OF SOURCE: Water pool; Two sources: (1) & (2).  
Sample can be placed in center of source  
or in several positions surrounding the source.

MAXIMUM ABSORBED  
DOSE RATE (in Si): (1)  $1 \times 10^4$  rad/h  
(2)  $4 \times 10^2$  rad/h

USABLE IRRADIATION VOLUME: 3" by 11" height

TEMPERATURE RISE DURING IRRADIATION: None

COST: \$100 (insertion + 24 hr) \$30 each addl. 24 hrs.

USER PRIVILEGES: User can operate after training

CONTACT: Mr. L.S. August  
Radiation, Beams, and Sources Section  
Code 6614  
Naval Research Laboratory  
Washington, DC 20375  
Telephone: (202) 767-3938



ORGANIZATION: Rockwell International  
Anaheim, CA

TYPE OF SOURCE: (1) AECL Gammacell 200  
(2) J.L. Shepard Model 109  
(3) J.L. Shepard Model 81  
(semicollimated source  
in shielded room)

MAXIMUM ABSORBED

DOSE RATE (in Si): (1)  $1 \times 10^6$  rad/h  
(2)  $9 \times 10^4$  rad/h  
(3) N/A

USABLE IRRADIATION VOLUME: (1) 3.5" dia. by 5" height  
(2) 4" dia. by 6" height  
(3) 12' x 12' room

TEMPERATURE RISE DURING IRRADIATION: N/A

COST: N/A

USER PRIVILEGES: N/A

CONTACT: Mr. Larry Green or Rick Halverson  
Rockwell International  
Defense Electronics Operations  
3370 Miroloma Ave., P.O. Box 3105  
Anaheim, CA 92803  
Telephone: (714) 632-0775

ORGANIZATION: Rome Air Development Center (RADC)  
Hanscom AFB, MA

TYPE OF SOURCE: Room source - 20 rods approximately  
12" long arranged in 5" diameter  
cylindrical array.

MAXIMUM ABSORBED  
DOSE RATE (in Si):  $5 \times 10^6$  rad/h

USABLE IRRADIATION VOLUME: Inside source - 5" dia. by 6" height.  
Room 8' by 8' by 12'

TEMPERATURE RISE DURING IRRADIATION: Cooling can be provided.

COST: Operator salary - \$218 to \$374 per day

USER PRIVILEGES: Supplies dosimetry and operates source.  
User supplies own equipment.

CONTACT: Mr. John Schott  
RADC/ESR  
Hanscom AFB, MA 01731  
Telephone: (617) 861-3445

ORGANIZATION: Sandia National Laboratories  
Albuquerque, NM

TYPE OF SOURCE: Gamma Irradiation Facility.  
Room source with sources in one  
corner of room.

MAXIMUM ABSORBED  
DOSE RATE (in Si):  $2 \times 10^6$  rad/h

USABLE IRRADIATION VOLUME: Room 8' by 8' by 8'.  
Inside source rods:  
7.5" by 5.5" by 9.5"

TEMPERATURE RISE DURING IRRADIATION: None

COST: \$85/hour

USER PRIVILEGES: Operator controls the source.  
User responsible for experimental setup  
and operation of experiment.

CONTACT: Dr. David Vehar  
Sandia National Laboratories  
Org 6452  
P.O. Box 5800  
Albuquerque, NM 87185  
Telephone: (505) 844-4820

ORGANIZATION: Southwest Research Institute Gamma Facility  
Southwest Research Institute  
San Antonio, TX

TYPE OF SOURCE: Two hot cells.  
Multiple configurations possible.

MAXIMUM ABSORBED  
DOSE RATE (in Si):  $3 \times 10^6$  rad/h

USABLE IRRADIATION VOLUME: 9' by 15' by 13'

TEMPERATURE RISE DURING IRRADIATION: 20°C in SS per Mrad/h

COST: Approx. \$500/day, negotiable

USER PRIVILEGES: Staff operated

CONTACT: Mr. David G. Cadena, Jr., Senior Research Physicist  
Department of Fuels and Lubricant Technology  
Southwest Research Institute  
6220 Culebra Road  
San Antonio, TX 78238  
Telephone: (512) 684-5111

ORGANIZATION: TRW, Inc.  
Redondo Beach, CA

TYPE OF SOURCE: (1) Gammacell 220  
(2) Gammacell 220

MAXIMUM ABSORBED  
DOSE RATE (in Si): (1)  $7 \times 10^5$  rad/h  
(2)  $1 \times 10^5$  rad/h

USABLE IRRADIATION VOLUME: 6" dia. by 8" height

TEMPERATURE RISE DURING IRRADIATION: (1) 32°C  
(2) None

COST: Depends on test.

USER PRIVILEGES: Facility operates irradiators.  
User may do own testing or in  
collaboration with facility staff.

CONTACT: Mr. Paul Guilfoyle  
TRW, Inc.  
MS 84/1002  
One Space Park  
Redondo Beach, CA 90278  
Telephone: (213) 535-0056

ORGANIZATION: University of Lowell  
Lowell, MA

TYPE OF SOURCE: Approximately 1 MCi plaque array  
of sources in H<sub>2</sub>O pool. Moved to 1/2" Al  
window for irradiations. 4 plugs and 4  
electrical conduits for access to experiment.

MAXIMUM ABSORBED  
DOSE RATE (in Si):  $5 \times 10^6$  rad/h

USABLE IRRADIATION VOLUME: 8' by 8' by 8'

TEMPERATURE RISE DURING IRRADIATION: Controlled by vent.

COST: Depends on test -- \$50/irradiation avg.

USER PRIVILIGES: University operates source.  
User runs own equipment.

CONTACT: Mr. Tom Wallace  
University of Lowell  
Radiation Laboratory  
1 University Ave.  
Lowell, MA 01854  
Telephone: (617) 452-5000

ORGANIZATION: University of Maryland  
College Park, MD

TYPE OF SOURCE: Room source. 10 source pencils in  
cylindrical array 3.25" in diameter.  
Sources stored in water, raised to  
irradiate position 30 inches above floor.

MAXIMUM ABSORBED  
DOSE RATE (in Si):  $9 \times 10^5$  rad/h

USABLE IRRADIATION VOLUME: In cylinder: 3" dia. by 12" height.  
Room: 15' by 15' by 10' high.

TEMPERATURE RISE DURING IRRADIATION: None

COST: Depends on test

USER PRIVILEGES: User operates own experiment

CONTACT: Dr. Walter J. Chappas  
University of Maryland  
Chemical Engineering Building  
College Park, MD 20742  
Telephone: (301) 454-8757

ORGANIZATION: White Sands Missile Range  
White Sands, NM

TYPE OF SOURCE: Room source. 1 to 10 cylindrical source capsules are transferred pneumatically from storage to head assembly. Samples can be placed in cavity in head assembly for maximum absorbed dose rate.

MAXIMUM ABSORBED  
DOSE RATE (in Si):  $10 \times 10^6$  rad/h

USABLE IRRADIATION VOLUME: 5 cm dia. cavity. Room: 12.8 meters by 6.1 meters by 3.7 meters high.

TEMPERATURE RISE DURING IRRADIATION: N/A

COST: Determined by test

USER PRIVILEGES: Facility operates source

CONTACT: Mr. Roland Penny  
White Sands Nuclear Effects Facility  
Gamma Radiation Facility  
White Sands Missile Range  
NM 88002  
Telephone: (505) 678-1161



U.S. DEPT. OF COMM. <b>BIBLIOGRAPHIC DATA SHEET</b> (See instructions)	<b>1. PUBLICATION OR REPORT NO.</b> NBSIR 86-3480	<b>2. Performing Organ. Report No.</b>	<b>3. Publication Date</b> NOVEMBER 1986
<b>4. TITLE AND SUBTITLE</b> Cobalt-60 Facilities Available For Hardness Assurance Testing			
<b>5. AUTHOR(S)</b> J. C. Humphreys and Charles M. Dozier			
<b>6. PERFORMING ORGANIZATION</b> (If joint or other than NBS, see instructions) National Bureau of Standards Gaithersburg, MD 20899			<b>7. Contract/Grant No.</b> DNA IACRO 86-816 <b>8. Type of Report &amp; Period Covered</b> Final
<b>9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS</b> (Street, City, State, ZIP) Defense Nuclear Agency Attn: (RAEV, Major R. C. Zittel) Washington, DC 20305			
<b>10. SUPPLEMENTARY NOTES</b>  <input type="checkbox"/> Document describes a computer program; SF-185, FIPS Software Summary, is attached.			
<b>11. ABSTRACT</b> (A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here)  This report contains a list of cobalt-60 gamma-ray irradiation facilities that are available for hardness assurance testing of electronic devices. A summary of source type, absorbed-dose rates, experimental volume available, and other pertinent information is given for each facility.			
<b>12. KEY WORDS</b> (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons) absorbed-dose rate, cobalt-60 facility, gamma rays, irradiation volume, radiation hardness testing.			
<b>13. AVAILABILITY</b> <input checked="" type="checkbox"/> Unlimited <input type="checkbox"/> For Official Distribution. Do Not Release to NTIS <input type="checkbox"/> Order From Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. <input checked="" type="checkbox"/> Order From National Technical Information Service (NTIS), Springfield, VA. 22161			<b>14. NO. OF PRINTED PAGES</b> 30 <b>15. Price</b> \$9.95





